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IDENTIFIERS Electrical Wiring; *Power Line Technicians

ABSTRACT

This module is the seventh in a series that is designed to help students achieve greater professional and personal success as power line technicians. Each module represents one or more complete units of instruction with components organized into one instructor and one student "package": the instructor's manual and the student workbook. The instructor's manual begins with a profile of training mastery that lists the competencies covered in the curriculum and provides space for recording information about the student's mastery of each objective. Other introductory matter includes information on use of the manual, recommendations for measuring student performance gains, and required criteria for a competency-based education program. The instructor's manual also contains one set per unit of these components: suggested activities, answers to assignment sheets, answers to test, transparency masters, and test. The student workbook contains one set per unit of most or all of these components: objective sheet, information sheets, assignment sheets, and job sheets. The three units in this module are as follows: (1) troubleshooting (primary line), (2) system knowledge (phase II), and (3) conversions. Most units are designed for use in more than one lesson or class period. (YLB)

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ED 403 416

Power Line Technician
Second Edition

Module G

Instructor's Manual
Student Workbook

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CE073253

Power Line Technician

Second Edition

Module G

- Troubleshooting (Primary Line)
- System Knowledge (Phase II)
- Conversions

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CIMC

Instructor's Manual

97-012246

Oklahoma Department of Vocational and Technical Education
1500 West Seventh Avenue
Stillwater, Ok 74074-4364
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TI1021

POWER LINE TECHNICIAN
PROFILE OF TRAINING MASTERY

Instructor _____ Date _____

Program _____

Grade _____ School _____

Name _____ Soc. Sec. No. _____

Address _____ Phone _____

In Case of Emergency, Contact _____

Address _____ Phone _____

Allergies/Disabilities that might require special accommodation for training (please specify) _____

The above information can be used for school records and/or to ensure safety of students. This confidential information is not to be released to employers or the general public.

Date of Enrollment ___-___-___ Total Class Hours _____ Total Hours Absent _____

Date of Withdrawal ___-___-___ Total On-the-Job Training Hours _____ Total Hours Tardy _____

Date of Completion ___-___-___ Total Lab Hours _____

ON-THE-JOB TRAINING/WORK EXPERIENCE

Duration of Employment	Job Title	Supervisor's Name
Address of Employer		Phone
Duration of Employment	Job Title	Supervisor's Name
Address of Employer		Phone

Use of This Document

This document can be used to record information about the student and skills mastered. This information is useful in documenting student progress during training and in providing information about the student's qualifications to potential employers and/or for entry into advanced training programs. Instructors using these materials are authorized to reproduce this document as required for use in their training programs.

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SPECIFIC JOB COMPETENCIES

Instructor: As each competency is mastered, place your initials and the date in the blank on the left. This will verify that the student can perform the skill with a minimum of supervision.

MODULE A

Unit 1 – Orientation to REC

Date/Initial

1. Match terms associated with REC orientation to the correct definitions.
2. State the reason for establishing the Rural Electrification Administration.
3. Discuss the importance of rural electric cooperatives.
4. Describe the benefits of rural electric cooperatives to rural America.
5. Select from a list the finance agencies which loan money to rural electric cooperatives.
6. List types of electric utilities.
7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 2 – Introduction to Power Line Technician's Training

Date/Initial

1. List responsibilities of a line technician to the community.
2. Select from a list the responsibilities of a line technician to the employer.
3. Select from a list information that is shown on an organizational chart.
4. List departmental functions of a line department.
5. Select from a list topics taught in this course.
6. List benefits to students who complete the line technician's training course.
7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 3 – Job Advancement

Date/Initial

1. Match terms associated with job advancement to the correct definitions.
2. List characteristics employers consider when making promotions.
3. Distinguish between good and poor work attitudes.
4. List steps that will help in job advancement.
5. Select from a list benefits of additional education and training.
6. Discuss activities that will better prepare a person for advancement.
7. Discuss reasons people do not succeed on the job.
8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 4 – General Safety

Date/Initial

1. State the safety responsibilities of an REC employee.
2. List the steps of discipline for safety rule violations.
3. Select from a list items which are subject to safety rules.
4. State reasons for the importance of a safety policy.
5. Discuss OSHA regulations for first aid.
6. List the basic steps in first aid.
7. List steps of basic life support.
8. List first aid supplies.
9. List the practices for care of first aid supplies.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

MODULE B

Unit 1 – Personal and Job Safety

Date/Initial

1. Match terms associated with personal and job safety to the correct definitions.
2. Describe the procedures to follow for various types of rescue situations.
3. List components necessary for fire.
4. Match classes of fires to the correct description of each.
5. Match types of fire extinguisher to the class or classes of fire each is best suited to extinguish.
6. List general safety precautions to observe during rescue.
7. Discuss in a short paragraph driving skills needed by a line technician.
8. List some poor attitudes that may cause accidents.
9. Select from a list requirements of a skilled driver.
10. List steps of defensive driving.
11. Identify shapes of traffic signs.
12. Select from a list some general safety precautions to observe when operating equipment.
13. State OSHA/DOT regulations for inspection of equipment.
14. Select from a list the items which should be inspected daily on mechanical equipment.
15. List methods for maintaining a clean and orderly work area.
16. Explain how to lift heavy objects.
17. Describe in a short paragraph the importance of safety communications.
18. Select from a list those items of importance that should be reported to the supervisor.
19. Select from a list items related to safety that a line technician should know concerning location and voltage.
20. State factors which determine the maximum weight which can be lifted by equipment.
21. Determine maximum weight that can be lifted by equipment at various angles.
22. Complete a safety pledge form.
23. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 2 – Communications

Date/Initial

1. List types of communications necessary for an REC employee.
2. Select from a list those items of communication that are important between fellow workers.
3. List items of communication that are important between the worker and the supervisor.
4. Select from a list those items of communication that are important between the worker and the general public.
5. Identify hoist signals.
6. Identify winch line signals.
7. Identify hand signals used in boom operations.
8. Identify hand signals used when maneuvering vehicles.
9. Identify line work signals.
10. Select from a list the proper radio procedures.
11. State emergency radio procedure.
12. Select from a list the prohibited uses of the radio.
13. Match radio code signal numbers to the correct meanings.
14. List factors that are important when using cellular mobile telephones.
15. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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Student ratings on specific competencies evaluated during the course are available upon student's written request and/or by calling the instructor. Parent's or guardian's signature is necessary if student is under 18 years of age.

Date/Initial

Unit 3 – Basic Electrical Theory

1. Match terms associated with basic electrical theory to the correct definitions.
2. List uses of electricity.
3. Discuss the electron theory.
4. Distinguish between alternating and direct current.
5. Match types of magnets to the correct descriptions.
6. State the law of magnetic poles.
7. Describe magnetic force as it relates to production of electricity.
8. Select from a list characteristics of electromagnetic force.
9. Explain the generation of electricity using magnets.
10. Describe electromagnetic induction.
11. Identify types of circuits.
12. Identify conditions of circuits.
13. Name sources of alternating and direct current.
14. Identify divisions of an electrical system.
15. State the relationship among amperage, resistance, and voltage.
16. Solve problems using Ohm's law.
17. Calculate for an unknown voltage.
18. Calculate for an unknown amperage.
19. Calculate for an unknown resistance.
20. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 4 – Rope and Rigging

1. Match terms associated with rope and rigging to the correct definitions.
2. Identify parts of a stationary block.
3. List kinds of rope used in line work.
4. Determine the tensile strength of various kinds and sizes of rope.
5. Determine the mechanical advantage of using block and tackle.
6. List uses of various types of rope gear.
7. Apply the formula necessary for the safe working load of various kinds and sizes of ropes when given the tensile strength and safety factory.
8. Identify various knots and hitches.
9. Match various knots and hitches with the correct uses.
10. Identify elements of knots, bends, and hitches.
11. List conditions that damage rope.
12. Calculate the mechanical advantage of using block and tackle.
13. Calculate working load of various ropes.
14. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 5 – Overhead Construction

1. Match terms associated with overhead construction to the correct definitions.
2. Match materials commonly used in overhead construction to their specific uses.
3. Identify hand tools commonly used in overhead construction.
4. Match hand tools to their specific uses.
5. Identify overhead construction tools.
6. Match overhead construction tools to their specific uses.
7. List elements of overhead construction.
8. List equipment used in overhead construction.
9. Match equipment commonly used in overhead construction to their specific uses.
10. Select from a chart the correct depth to set poles of varying lengths.
11. List methods used to properly sag conductors.
12. Identify various types of connectors used in overhead construction.
13. Match types of construction to the correct descriptions.
14. List steps to properly install a pole key.
15. State correct procedure for installing a ground rod.
16. Arrange in order the steps to follow when framing a pole.
17. Identify various structures used in transmission line construction.
18. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 6 – Underground Distribution Construction

1. Match terms associated with underground construction to the correct definitions.
2. Identify equipment used in underground construction.
3. Match various types of equipment to the specific uses.
4. List general requirements for underground construction.
5. Arrange in order the correct procedure for installing cable.
6. List precautions to observe when handling underground cable.
7. Select from a list methods of marking cable for identification.
8. List methods used to locate and identify a utility ditch.
9. Identify equipment used to terminate primary cable on a pole.
10. State the requirement for grounding underground equipment.
11. List hazards which may be encountered in underground construction.
12. List precautions to observe when splicing or terminating cable.
13. Select from a list the tools used in underground construction.
14. Make a proper splice in secondary cable.
15. Make a proper splice in primary cable.
16. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 7 – Personal Climbing Tools and Equipment

1. Match terms associated to personal climbing tools and equipment to the correct definitions.
2. Identify personal climbing tools and equipment.
3. Match tools and equipment to the specific use.
4. List conditions to watch for when inspecting personal climbing tools and equipment.
5. Name types of maintenance for personal climbing tools and equipment.
6. List safety precautions to observe when climbing poles.
7. Select from a list the general procedure for climbing poles.
8. Name rules for safe and proper storage of personal tools and equipment.
9. Climb poles.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 8 – Right-Of-Way

1. Match terms associated with right-of-way clearing and control to the correct definitions.
2. List methods to maintain good public relations.
3. Identify tools used for right-of-way clearing and control.
4. State the purposes of right-of-way control.
5. Select from a list the safe working procedures for right-of-way clearing and control.
6. Select proper methods of tree trimming.
7. List steps to remove limb hanging over an energized conductor.
8. List steps to fell a tree.
9. State the specifications for clearing right-of-way for distribution line.
10. List types of clearing and chemical control for right-of-way.
11. Identify various trees that grow rapidly.
12. Identify poisonous vegetation.
13. Draw cuts needed to remove heavy limbs.
14. Draw procedure for removing limb hanging over energized conductor.
15. Draw procedure for felling a tree.
16. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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Date/Initial

Unit 9 – Distribution Transformers

1. Match terms associated with transformers to the correct definitions.
2. State the functions of a transformer.
3. Identify parts of a completely protected transformer.
4. Distinguish between additive and subtractive polarity as they relate to transformers.
5. List kinds of transformers.
6. Match types of transformers to the correct descriptions.
7. Classify types of transformers as oil-cooled or air-cooled.
8. Discuss technical considerations in protective grounding and jumpering.
9. List information found on a transformer nameplate.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

MODULE C

Date/Initial

Unit 1 – Poles

1. Match terms associated with poles to the correct definitions.
2. List five types of preservatives used on poles.
3. Match the type of preservatives used on poles with their code letters.
4. Select from a table the classes of poles of varying lengths and circumferences.
5. Select from a list precautions to observe when handling poles.
6. Calculate the weights of various classes and lengths of commonly used poles using a table.
7. List methods used to set poles.
8. State the correct procedure for checking a pole before climbing.
9. Arrange in proper order the steps for pole inspection.
10. List methods used to support unsafe poles for climbing.
11. State the correct method for storing poles.
12. Select from a table the classes of poles of varying lengths and circumferences.
13. Calculate the weights of various classes and lengths of commonly used poles using a table.
14. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 2 – Conductors

1. Match terms associated with line conductors to the correct definitions.
2. List methods used to protect line conductor at supports.
3. Arrange in order the steps to follow when joining ACSR conductors.
4. Arrange in order the steps to follow when joining CWC conductors.
5. List classes of conductors.
6. List methods of reeling our conductor.
7. Identify various types of conductor ties.
8. Match types of conductors to their specific use.
9. State conductor clearance from ground, roofs and building walls for conductors carrying 750 volts or less.
10. State conductor clearance from ground for conductors carrying over 750 volts to 22,000 volts.
11. Match current-carrying capacities of various ACSR conductors to the correct conductor size.
12. Match current-carrying capacities of various copperweld copper conductors to the correct conductor size.
13. Install a preformed line tie on ACSR conductor on a de-energized circuit.
14. Install a top groove conductor tie on a de-energized copper conductor.
15. Install a preformed armor rod on ACSR conductor.
16. Join ACSR conductor.
17. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 3 – Grounding and Connecting

1. Match terms associated with grounds and connectors to the correct definitions.
2. State the purposes of grounding.
3. List methods of grounding.
4. Select from a list those elements necessary for good grounding.
5. Select from a list equipment which must be grounded.
6. State the correct procedure for installing temporary protective grounds.
7. Arrange in order the steps to follow when disconnecting and grounding at sectionalizer or recloser station.
8. Arrange in order the steps to follow when disconnecting and grounding at multiphase vertical corner.
9. State the procedure for installing temporary protective grounds at air-break switch on a transmission line.
10. List elements of a good connection.
11. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 4 – Generators and Batteries

1. Match terms associated with generators and batteries to the correct definitions.
2. List kinds of generating plants.
3. Match kinds of generators to the voltages produced by each.
4. Match kinds of generators to the specific uses.
5. Calculate the frequency (Hertz) of various generators.
6. List precautions to observe with the use of portable generators.
7. List types and kinds of voltage-producing cells.
8. Identify various circuits of connected batteries.
9. Select from a list precautions to observe when connecting batteries.
10. Arrange in order the steps to follow to connect lead-acid batteries when starting equipment.
11. Connect batteries in series and parallel.
12. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 5 – Work Procedures (Nonenergized)

1. Match terms associated with work procedures to the correct definitions.
2. Select from a list information found on a staking sheet.
3. Arrange in proper order the procedure for line construction.
4. List steps to follow when installing service wire.
5. State the procedure for connecting service wire.
6. Match the materials needed to construct primary and neutral assemblies using ACSR conductor 7.2kV construction.
7. List materials needed to install various pole ground assemblies.
8. List materials needed for various primary assemblies.
9. List materials needed to complete a work order.
10. Identify section numbers within a township.
11. Locate rural property in Oklahoma using legal descriptions.
12. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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MODULE D

Unit 1 – Insulation

Date/Initial

1. Match terms commonly associated with insulators and insulation to their correct definitions.
2. List steps to follow when installing a pin type insulator.
3. Select from a list methods of insulating distribution voltages.
4. Select from a list methods of insulating various transmission voltages on wooden structures.
5. Match insulative materials to their specific uses.
6. Select from a list precautions to observe with insulators and insulation.
7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 2 – Substations

Date/Initial

1. Match terms commonly used with substations to the correct definitions.
2. State functions of a substation.
3. Identify components of a substation.
4. Match components of a substation to their specific use.
5. Arrange in order the steps for taking a substation out of service.
6. Select from a list precautions to observe with a substation.
7. Arrange in order the correct procedure for changing a substation oil circuit recloser.
8. State the correct procedure for bypassing a substation current transformer.
9. List indications in a substation that could cause an outage.
10. Match indications to problems which may occur in substations.
11. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 3 – Ground and Jumpers (Line Equipment)

Date/Initial

1. Match terms commonly used with grounds and jumpers to the correct definitions.
2. Match types of jumpers to their specific use.
3. State requirements for various jumpers.
4. Select from a list the line equipment that is connected by jumpers.
5. Match types of jumpers to the correct installation methods.
6. State the requirements for safe grounding of line equipment.
7. Distinguish between proper and improper grounding methods.
8. Calculate current flow of faulted equipment which is improperly grounded.
9. Calculate voltage on improperly grounded faulted equipment.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 4 – Voltage and Current Measuring

Date/Initial

1. Match terms commonly used with voltage and current measurements to the correct definitions.
2. State the purposes of voltage and current measurements.
3. Identify equipment used for voltage and current measurements.
4. State the correct procedure for determining voltage drop of a service.
5. State the correct procedure for determining current demand on a primary circuit in a specific area.
6. State procedures for determining current demand on a transformer.
7. List steps to obtain primary line voltage drop.
8. Select from a list reasons for current measurements.
9. Match full load secondary current at 240 volts single phase to the kVA ratings of a transformer.
10. Select from a list precautions to observe when making voltage and current measurements.
11. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

MODULE E

Unit 1 – Meters and Meter Application

Date/Initial

1. Match terms commonly associated with metering to the correct definitions.
2. List general types of meters.
3. List types of meters by base construction.
4. List classes of meters and the current-carrying capacity of each.
5. Match meters to types of service.
6. Match meter to voltage ratings to types of service.
7. Match abbreviations and symbols used with metering circuit diagrams to the correct meanings.
8. List uses of current transformer metering.
9. List uses of self-contained meter connections.
10. Identify various self-contained meter connections.
11. Identify various transformer-rated meter connections.
12. Identify various transformer-rated meter connections for 600 volts or above.
13. State the procedure for selecting the correct meter.
14. List methods for determining voltage for wye and delta connected meters.
15. Match types of services to specific uses.
16. List types of meters which have multipliers.
17. Arrange in order the correct procedure for determining meter multipliers.
18. List precautions to observe with metering.
19. Calculate the multiplier for a transformer-rated meter connected to a secondary line.
20. Calculate the multiplier for a transformer-rated meter connected to a primary line.
21. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Unit 2 – System Knowledge

Date/Initial

1. Match terms used with system knowledge to the correct definitions.
2. Define symbols used with overhead lines and equipment identification on system maps.
3. Define symbols used with underground lines and equipment identification on system maps.
4. Identify symbols used to locate cultural features on system maps.
5. List functions of automated equipment.
6. List precautions to observe with automated equipment.
7. Select from a list conditions associated with system terrain.
8. Identify symbols on a system map.
9. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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Date/Initial

Unit 3 – Transformer Connections and Banking

1. Match terms commonly used with transformer connections and banking to the correct definitions.
2. Define characteristics of transformer construction.
3. Match symbols used with transformer voltage rating and connection diagrams to the correct meanings.
4. Discuss transformer polarities.
5. Discuss bushing locations in relationship to polarity on padmount transformers and compare to pole-type in regard to subtractive and additive.
6. Identify secondary coil connections for two- and three-wire service.
7. Identify single-transformer connections for three-wire service.
8. Identify two-transformer banks.
9. Define objectives an electrician must keep in mind when constructing three-phase banks.
10. List in order the step-by-step process for designing three-phase banks.
11. Describe phase relationships between the bushings in three-phase banks.
12. Identify types of primary and secondary connections for three-transformer banks.
13. List precautions to observe when selecting transformers to be banked or paralleled.
14. Identify secondary connections on a four-bushing transformer.
15. State the correct method of connecting wye and delta transformers to a primary line.
16. Arrange in order the steps to find a faulted transformer in a bank.
17. State the precautions to observe with transformer banks.
18. Connect transformer secondary coils in series and parallel.
19. Connect a wye-delta bank for three-phase four-wire 120/240-volt service.
20. Connect a wye-delta bank for three-phase three-wire 240-volt service.
21. Connect a wye-wye bank for three-phase four-wire 120/208-volt service.
22. Connect an open-wye open-delta bank for three-phase four-wire 120/240-volt service.
23. Connect an open-wye open-delta bank for three-phase three-wire 240-volt service.
24. Connect an open-delta open-delta bank for three-phase four-wire 120/240-volt service.
25. Connect two single-bushing transformers in parallel.
26. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 4 – Phasing

1. Match the terms commonly associated with phasing to the correct definitions.
2. List elements of phasing.
3. State methods of determining phase rotation.
4. State the procedure for changing the direction of rotation of a three-phase motor.
5. Arrange in order the steps to follow when phasing circuits with a phasing meter.
6. Arrange in order the steps to follow to identify distribution phases.
7. Label substation distribution phases.
8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

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MODULE F

Date/Initial

Unit 1 – Line Patrol

1. Match types of line patrol to the specific purpose.
2. Select from a list items to observe when patrolling line.
3. Match items to the specific conditions to observe when patrolling a line.
4. List methods of line patrol.
5. Select from a list requirements of a line patroller.
6. List items to observe with line equipment.
7. Complete a line inspection form.
8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 2 – Electrical Equipment

1. Match terms used with electrical equipment to the correct definitions.
2. Match electrical equipment to the specific uses.
3. Arrange in order the steps to follow when connecting a voltage regulator to a three-phase line.
4. Arrange in order the steps to follow when placing a voltage regulator in service.
5. State the procedure for setting voltage regulator time delays.
6. State the procedure for taking a voltage regulator out of service.
7. List precautions to observe with voltage regulators.
8. List precautions to observe with capacitors.
9. Select from a list the benefits of capacitor application.
10. Name equipment that should be protected by lightning arresters.
11. Explain the method of coordinating reclosers with other reclosers.
12. List precautions to observe when installing sectionalizers.
13. Select from a list factors to consider when coordinating reclosers and fuses.
14. Connect voltage regulators to a three-phase line.
15. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 3 – Work Procedures (Hot Line, Basket, Hot Stick)

1. List methods of hot line maintenance.
2. Select from a list OSHA requirements for aerial devices.
3. Select from a list rules to observe when working with aerial devices.
4. List elements of hot line maintenance.
5. State the procedure for hot line maintenance from an aerial device.
6. Arrange in order the steps to follow when changing a pole top insulator from a basket.
7. Match various hot line tools to their specific uses.
8. Install a wire tong saddle.
9. Change an insulator on an energized conductor using hot line tools on an A1 structure.
10. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 4 – Troubleshooting (Secondary)

1. Match terms associated with troubleshooting to the correct definitions.
2. Match indications of malfunctions to the possible causes.
3. Arrange in order the correct procedure for troubleshooting electrical equipment.
4. List precautions to observe when troubleshooting electrical equipment.
5. Select from a list items of information to obtain while troubleshooting.
6. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

MODULE G

Date/Initial

Unit 1 – Troubleshooting (Primary Line)

_____ 1. Match troubleshooting problems to possible causes.
_____ 2. Arrange in order the troubleshooting procedures to follow for various problems.
_____ 3. List precautions to observe when troubleshooting primary lines.
_____ 4. Arrange in order the steps for troubleshooting a primary line outage.
_____ 5. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 2 – System Knowledge

_____ 1. List problems associated with line switching.
_____ 2. Arrange in order the steps to follow when switching line.
_____ 3. List factors involved in line switching.
_____ 4. Select from a list precautions to observe with line voltage regulators on a switched line.
_____ 5. List precautions to observe when opening a line switch.
_____ 6. Select from a list areas and locations of importance to the line technician.
_____ 7. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

Date/Initial

Unit 3 – Conversions

_____ 1. List types of conversions.
_____ 2. Arrange in order the steps to convert a primary line to a higher voltage.
_____ 3. Arrange in order the steps to change a substation feed area to a higher voltage.
_____ 4. Explain benefits of converting to a higher voltage.
_____ 5. Select from a list precautions to observe with autotransformers.
_____ 6. Arrange in order the steps to convert a single-phase line to V-phase.
_____ 7. Arrange in order the steps to convert a single-phase line to three-phase.
_____ 8. _____

Pretest Score (%) _____

Post Test Score (%) _____

Modified Gains Score (%) _____

BEST COPY AVAILABLE

Power Line Technician: Module G

Instructor's Manual

Upfront

Suggested Activities

Answers to Assignment Sheets

Answers to Test

Transparency Masters

Test

Developed by the
Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and Technical Education

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Curriculum and Instructional Materials Center

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Instructor's Manual

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One set per unit of the following components:

- Suggested Activities
- Answers to Assignment Sheets
- Answers to Test
- Transparency Masters
- Test

Student Workbook

One set per unit of Objective Sheets, Information Sheets, Assignment Sheets, and Job Sheets for each of the units in this module:

MODULE A

1. Orientation to REC
2. Introduction to Power Line Technician's Training
3. Job Advancement
4. General Safety

MODULE B

1. Personal and Job Safety
2. Communications
3. Basic Electrical Theory
4. Rope and Rigging
5. Overhead Construction
6. Underground Distribution Construction
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9. Distribution Transformers

MODULE C

1. Poles
2. Conductors
3. Grounding and Connecting
4. Generators and Batteries

5. Work Procedures (Nonenergized)

MODULE D

1. Insulation
2. Substations
3. Grounds and Jumpers (Line Equipment)
4. Voltage and Current Measuring

MODULE E

1. Meters and Meter Application
2. System Knowledge
3. Transformer Connections and Banking
4. Phasing

MODULE F

1. Line Patrol
2. Electrical Equipment
3. Work Procedures (Hot Line, Basket, Hot Stick)
4. Troubleshooting (Secondary)

MODULE G

1. Troubleshooting (Primary Line)
2. System Knowledge (Phase II)
3. Conversions

FOREWORD

The *Power Line Technician* series is designed to help students achieve greater professional and personal success. As a tool for building a rewarding career, this series will help students develop their professional competence. In addition, the series provides a foundation for career advancement. The *Power Line Technician* series consists of seven modules which address specific skill areas. Each module represents one or more complete units of instruction with components organized into one student and one instructor "package": the *Student Workbook*, and the *Instructor's Manual*. We believe the format and packaging will facilitate both the delivery and mastery of the identified competencies.

We hope that this series will enhance instruction and contribute to rewarding learning experiences for all students.

Roy Peters, Jr.
State Director
Oklahoma Department of
Vocational and Technical Education

Ivan Armstrong
State Supervisor
Trade and Industrial Education

ACKNOWLEDGMENTS

The Curriculum and Instructional Materials Center (CIMC) extends its appreciation to the individuals who played key roles in the development of this publication. Such a comprehensive effort requires contributions from many people. We sincerely appreciate the support necessary to complete this project.

Design: Special thanks are extended to the representatives from industry, teaching, and vocational education who participated as members of the curriculum advisory committees for the *Power Line Technician* series. We also thank the administrators, supervisors, and others who supported their participation. Significant contributions were made during the revision process by participants from ABB Power T&D Company Inc., the Association of Missouri Electric Cooperatives, the Central Rural Electric Cooperative (Stillwater, Oklahoma) and the City of Stillwater.

Development: The modules in this series were edited by Craig Maile and Dr. Lois Sharpton. Individual modules were formatted by Vonda Gile. Brenna Tillman, Publications Supervisor in the CIMC, assisted in adapting the packaging.

Production: The close cooperation and dedication of professionals at the Oklahoma Department of Vocational and Technical Education were instrumental in producing the *Power Line Technician* series. Unit and cover artwork were designed by the Art Department, under the direction of Bob Davis, Art Manager. This series could not have been printed without the expertise and commitment of the Printing Plant Staff, under the direction of Danny Darrow. Delivering the final product was accomplished through the excellence of the CIMC Customer Service staff and the staff of the CIMC Warehouse, under the direction of Darrell Stiles.

Support: A number of people at the CIMC helped to make this series possible. Terri Tomson efficiently handled the development contracts, committee meetings, and correspondence relating to this series. This project also received generous support from John Friedemann, CIMC Team Leader, and Dr. Lynna Ausburn, Development Coordinator.

Project Management: Dr. Marilyn Troupe and Craig Maile

USE OF THIS PUBLICATION

Each unit of instruction is based on the performance needed for successful employment in an occupational area. A complete unit will contain most or all of the following components: Objective Sheet, Suggested Activities, Information Sheet, Assignment Sheet, Job Sheet, Test, Answers to Assignment Sheets, Answers to Test, and Transparency Masters. These components are organized within two packages, as follows:

Instructor's Manual

- Upfront pages
- One set per unit of:
  - Suggested Activities
  - Answers to Assignment Sheets
  - Answers to Test
  - Transparency Masters
  - Test

Student Workbook

- Objective Sheets
- Information Sheets
- Assignment Sheets
- Job Sheets

Instructor's materials include the *Instructor's Manual* and the *Student Workbook*.

Unit components are tied to measurable and observable learning outcomes. Instructors are encouraged to supplement unit components with other resources to make units as responsive to local conditions and student needs as possible.

Most units of instruction are designed for use in more than one lesson or class period. Instructors should determine the following for each unit:

- amount of material that can be covered in each class period;
- skills that must be demonstrated;
- supplies and equipment needed;
- amount of class time needed for demonstrations;
- amount of class time needed for student practice;
- supplementary materials to be ordered; and
- resource persons who must be contacted.

Objective Sheet (Student Workbook)

The Objective Sheet summarizes each unit for the student and the instructor. The Objective Sheet includes the following sections:

> **Unit Objective** – The Unit Objective states the overall goal of the unit. It identifies what the student will be able to do after successfully completing the unit, as well as the standards used to measure student performance.
>
> **Specific Objectives** – The Specific Objectives outline the teaching sequence of the competencies required to reach the Unit Objective.

The Specific Objectives on the Objective Sheet should be emphasized to all students at the start of each unit and throughout the teaching/learning process. This will help answer student questions about performance requirements for each unit. Specific Objectives can also assist instructors in determining teaching strategies and instructional methods. Instructors should prepare for each unit by deciding how each objective could best be taught.

Instructors should modify, delete, or add objectives to meet the needs of students and the community. When objectives are added, the instructor should remember to provide the needed information, Assignment and/or Job Sheets, and criterion-referenced test items to cover the new objectives.

Information Sheet (Student Workbook)

The Information Sheet provides the "must know" content essential for meeting the cognitive objectives in the unit. The Information Sheet may include clarifying NOTES and EXAMPLES, as needed. Students should read the Information Sheet for each unit before it is discussed in class.

Assignment Sheets (Student Workbook)

The Assignment Sheets address the learning levels at or above the application level of Bloom's taxonomy. They allow students to perform non-psychomotor activities related to occupational tasks. Assignment Sheets also provide students with an opportunity to use higher-order thinking skills, such as problem-solving, synthesizing, analyzing, and evaluating. In addition, they may provide opportunities for cooperative learning and more detailed oral/written communication activities.

Job Sheets (Student Workbook)

Job Sheets give students step-by-step procedures for performing manipulative or psychomotor occupational tasks or jobs. The Job Sheet also facilitates the instructor's evaluation of each student's performance. Both the process and the end-product are evaluated. Diagrams, illustrations, and photographs are included, as needed, to assist students in completing the job.

The instructor should demonstrate the procedure outlined in each Job Sheet. Instructors may also have to localize specific procedures.

Suggested Activities (Instructor's Manual)

Instructors should study the Suggested Activities before introducing the unit, allowing enough time to obtain supplemental materials, prepare audiovisual materials, and contact outside resource persons. Specific tasks of the instructor will vary with each unit.

Answers to Assignment Sheets and Answers to Test (Instructor's Manual)

These components list the answers to all of the Assignment Sheets and the Test questions.

Transparency Masters (Instructor's Manual)

Transparency Masters are provided so that instructors can make transparencies to accompany specific units. Transparencies allow students to *see* as well as hear the information being presented, thus reinforcing the learning process. They also direct attention to the topic under discussion. Transparencies should be left on the screen only when the related topics are under discussion.

Test (Instructor's Manual)

The Test provides criterion-referenced evaluation of the Specific Objectives from the Information Sheet (Assignment Sheet and Job Sheet objectives are not evaluated by the Test). If instructors have added, deleted, or modified any objectives, appropriate changes should be made to the Test as well.

The Test serves as both a pretest and a posttest. In order to measure and document student competency gains as required by the latest Carl Perkins regulations, and as outlined in the Oklahoma-developed system of standards and measures, it is *essential* that the same test be used as a pretest and as a posttest. If instructors choose to use tests other than the unit Test, they should make sure that the same instrument is used for each activity – pre- and posttest.

A detailed explanation of the Oklahoma plan for standards and measures and the Carl Perkins requirements is included in the CIMC publication *Measuring Learning & Competency Gains: The Pretest/Posttest Approach.* This booklet – and accompanying software to assist in calculating and recording student gains – are available to Oklahoma instructors through their school's vocational testing liaison.

Profile of Training Mastery

The Profile of Training Mastery documents student performance. Each profile lists the competencies covered in the curriculum, and provides space for recording information about the student and the student's mastery of each objective. Space is also provided for recording pre- and posttest scores, modified gains, and instructor comments. A blank Profile of Training Mastery is available for this series. It may be reproduced for each student.

Page Numbering

Each Module is identified with a letter (A - G). Each unit and page has a number, shown in Arabic numerals. For example, the page number for Module A, Unit 2, page 3 of the *Student Workbook* would appear as follows:

PLT A - 2 - 3

Methods of Disseminating Material

For best results, provide each student with a copy of the Student Workbook. Students should be allowed to keep their Workbooks at the end of the course or training program.

Teaching Methods

Keeping students motivated is a challenge. Supplement each unit with current information, personal experiences, and other information. In a group setting, prepare for each unit by determining the best way to teach each objective, and allow for student input. For individualized instruction, provide opportunities for the student to become involved in planning and being responsible for his or her own education.

MEASURING STUDENT PERFORMANCE GAINS

Each CIMC unit contains only a single unit Test. This test should be used as **both** pretest and posttest by giving it once before students start a unit and again when they have completed the unit.

The reason for using a single instrument as both pretest and posttest is so that direct comparison of each student's competencies before and after instruction can be made accurately. This comparison enables precise calculation, documentation, and evaluation of student **performance gains**.

Accurate performance gains analysis is an important requirement of the new Carl Perkins legislation for vocational education. Teachers can make an important contribution to the performance accountability mandated by the new federal legislation by carrying out accurate performance gains analysis for their students, and making this data available to students, parents, and administrators.

This analysis is easy to do and requires only simple calculations and record keeping. Detailed information regarding performance gains analysis is contained in the CIMC publication, *Measuring Learning & Competency Gains: The Pretest/Posttest Approach*. In addition, the CIMC has developed a computer program, CARL, which will perform all necessary calculations and will print out a record form of all information required for gain score analysis. Copies of CARL and the publication are available through your local testing liaison (in Oklahoma), or from the CIMC at 1-800-654-4502.

REQUIRED CRITERIA FOR A COMPETENCY-BASED EDUCATION PROGRAM

Criterion	**Discussion**	**CIMC component meeting criterion**
1. Instruction is based on clearly-stated learning objectives that are: a) observable and measurable, and b) communicated in writing to students before instruction begins.	Learning objectives drive CBE. Objectives are the "competencies" that learners must achieve. Each objective must clearly state what *learners* must *do* to demonstrate acquired skill or knowledge. Verbs in learning objectives are active and precise, stating the exact performance expected of learners. The objectives should also specify the standard or level of performance required. Objectives can be at any level of Bloom's Taxonomy and can include the cognitive, psychomotor, and affective domains. Higher-order cognitive skills should be included.	Objective Sheet
2. Instruction is aligned with the stated learning objectives.	In CBE, the objectives specify what is taught. "Content" should relate to one or more objectives. The curriculum should cover all objectives with relevant information.	Information Sheet
3. There is a student evaluation system that is: a) criterion-referenced, and b) aligned to the learning objectives and the curriculum.	In CBE, the aim is to bring the performance of *all* learners up to a pre-defined standards and competencies. Learners work on each competency until they achieve "mastery"; the evaluation system should test and record this mastery. Learners can restudy and retest as often as needed. Specific remediation activities should also be available to learners when needed. The evaluation system focuses on what each student has achieved, not on what the instructor has "taught." The "constant" in CBE is student performance; the "variables" are time and resources. (This differs from traditional systems where learners get one chance at mastery; some succeed and some fail. In such systems, time and resources are constant and student achievement is variable.) If an evaluation is criterion-referenced, successful learner performance is defined by (or *referenced* to) mastery of pre-set objectives and standards (or *criteria*): there must be a careful match (or *alignment*) between what the student should master (objectives), what is taught (curriculum), and what is tested. Objectives, curriculum, and evaluation system must all match.	Test and Job Sheet

Criterion	Discussion	CIMC component meeting criterion
4. There is an observable management system of cognitive skill practice that provides for, promotes, and documents mastery learning.	For both cognitive and psychomotor skills, a CBE program must have a system of maintaining records of which skills and activities each learner has completed, which ones are in progress, and which ones have not yet been completed. Completion means "mastery"; no skill is completed until the learner has achieved the mastery level. The record system should promote feedback on student skill attainment to *both* instructor and learners, provide for remediation as needed, and encourage reevaluation of learner performance until mastery is achieved. Appropriate remediation strategies often should consider learning styles and other individual differences among learners. Learners should work on skills and activities until they achieve mastery. They should not be "passed on" without mastery. While learners may move ahead and work on other skills (i.e those for which all prerequisite skills have been mastered or those without prerequisites), work should also continue on the skills still requiring mastery. Students should not attempt higher-order skills until all prerequisite skills are mastered.	Assignment Sheet
5. There is an observable management system of psychomotor skill practice that provides for, promotes, and documents mastery learning.		Job Sheet
6. Skill mastery records are maintained for each learner, and learners have access to and make use of these records to monitor their skill acquisition.	Records should clearly indicate the skills each learner has mastered. One such record should profile or list the competencies that have been mastered and those to be mastered. Other performance indicators can be added and kept in a portfolio for each learner. Learners should have ready access to their portfolios to monitor their own progress in skill mastery and competency attainment.	Profile of Training Mastery

CORRECTIONS AND SUGGESTIONS

The Curriculum and Instructional Materials Center (CIMC) wants to provide vocational instructors and students with accurate and effective materials. Although the CIMC strives to maintain the highest standards of development and production, oversights sometimes do occur. If you find any errors in this or other CIMC publications, or have suggestions for improving their usefulness in vocational programs, please notify the CIMC staff. To do this, please identify the page(s) affected and write any comments to clarify the error or suggestion. Use the spaces below. Then, simply fold (bottom of page *upward*, top *downward*), secure, and mail.

This information will be used to correct the publication before the materials are reprinted. To ensure that the material is updated on a timely basis, notify the CIMC of necessary corrections as soon as possible after discovering the error.

[2] Fold downward

Page: Comment:

[1] Fold upward

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TROUBLESHOOTING
(PRIMARY LINE)
UNIT 1

SUGGESTED ACTIVITIES

1. Suggested activities for instructor:

   - Provide student with objective sheet.
   - Provide student with information sheet.
   - Make transparency.
   - Discuss unit and specific objectives.
   - Discuss information sheet.
   - Give test.

2. Unit references:

   - *Power Line Technician.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

TROUBLESHOOTING
(PRIMARY LINE)
UNIT 1

ANSWERS TO TEST

1. a. 6
   b. 7
   c. 1
   d. 3
   e. 5
   f. 2
   g. 4

2. a. Low line voltage

   4, 6, 3, 1, 2, 5

   b. Blinking lights

   6, 2, 1, 5, 4, 3

   c. Extreme voltage swing

   2, 1, 4, 3

   d. Line outage

   3, 1, 2

   e. Radio and television interference

   1, 5, 3, 2, 4

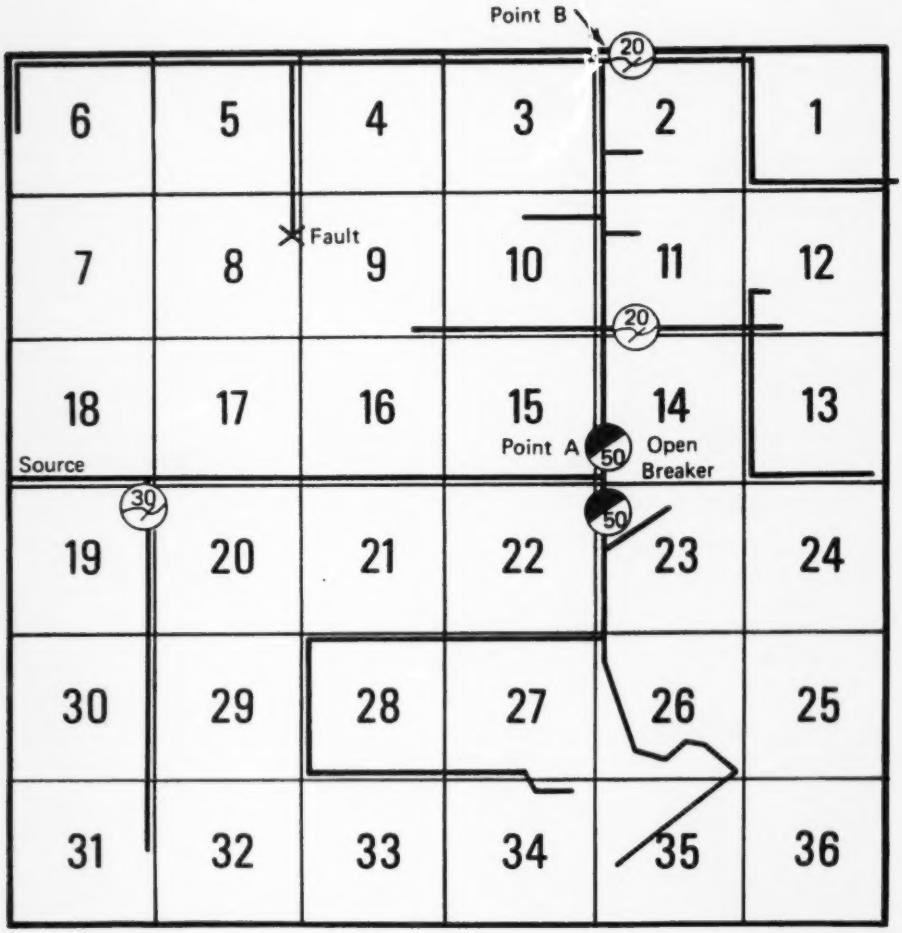
   f. High line voltage

   2, 1

3. a. Assume all conductors are energized unless grounds are installed within sight
   b. Do not place yourself in series with an open neutral or ground
   c. Wear your personal protective equipment
   d. Place hold card at disconnect point

4. 5, 1, 6, 4, 3, 7, 2

Troubleshooting A Primary Line Outage (Example)



Example: Troubleshooting a primary line outage which occurs at Point "A"

1. Reset breaker at Point "A"
2. Patrol line to Point "B" if breaker does not hold
3. Open the line at Point "B" if fault is not located
4. Reset breaker at Point "A"
5. Patrol line from Point "B" to end of line
6. Locate fault, install protective grounds, and repair fault

TM 1

May be photocopied for student use.

TROUBLESHOOTING
(PRIMARY LINE)
UNIT 1

TEST

NAME _____ SCORE _____

1. Match troubleshooting problems on the right to the possible causes.

_____a. Line overloaded; voltage regulator inoperative; capacitors not in operation; backfeed on open line from another source

_____b. Voltage regulator inoperative; too much capacitance on the line

_____c. Broken or burned connection; cattle rubbing down guy; trees blowing into line; contact with another line; swinging phase; broken insulator

_____d. Intermittent heavy load on line; oil field pumps not balanced; voltage regulator inoperative; open phase or phases in common

_____e. Loose or burned connection; transformer breaking down; insulator breaking down; loose hardware; broken or loose pole ground; ground wire too close to hardware

_____f. Pipeline rectifier set too high; poor ground condition; high wattage radio station nearby; dissimilar metals underground

_____g. Small animal or bird on conductor; trees in line; cattle rubbing down guy; lightning; downed pole; broken insulator; lightning arrester shorted; gap set too close on lightning arrester; high wind blowing foreign objects into line; transformer faulted; breaker faulted; broken conductor

1. Blinking lights
2. Galvanic damage
3. Extreme voltage swing
4. Line outage
5. Radio and television interference
6. Low line voltage
7. High line voltage

May be photocopied for student use.

TEST

2. Arrange in order the troubleshooting procedures to follow for various problems. Place a "1" before the first procedure, a "2" before the second procedure, and so on.

a. Low line voltage

_____ Check line capacitors

_____ Record information

_____ Check voltage regulator

_____ Measure line amperage

_____ Check conductor size

_____ Check reclosers

b. Blinking lights

_____ Check with consumers along the line to locate source of blinking

_____ Check for trees in the line

_____ Inspect line visually for loose or burned connections

_____ Set recording voltmeters along the line

_____ Check for swinging phase

_____ Patrol line for signs of cattle rubbing down guys

c. Extreme voltage swing

_____ Check for open phase or phases in common

_____ Check for heavy intermittent load

_____ Check voltage regulator for proper operation

_____ Check for oil field or other types of unbalanced pumps

d. Line outage

_____ Reset the breaker or re-fuse the line

_____ Locate consumer on your system map

_____ Trace phase to which consumer is connected to breaker or fuse which protects that phase

May be photocopied for student use.

TEST

e. Radio and television interference

_____ Check with consumers to find radius of interference

_____ Check fence chargers in the area

_____ Check for loose connections

_____ Use radio or noise locator to localize the source of interference

_____ Disconnect transformer to see if interference source is on a secondary or in the transformer

f. High line voltage

_____ Check line capacitors

_____ Check voltage regulator

3. List precautions to observe when troubleshooting primary lines. Key words are provided.

a. Assume — _____

_____

b. in series — _____

_____

c. Wear — _____

_____

d. hold card — _____

_____

4. Arrange in order the steps for troubleshooting a primary line outage. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Disconnect transformers and taps in the section of line that is faulted

_____b. Reset the open breaker

_____c. Reconnect line at mid-point with a temporary fuse holder

_____d. Return to open breaker and reset it

May be photocopied for student use.

TEST

_____e. Open line at mid-point if the fault is not located

_____f. Reconnect transformers and taps with a temporary fuse holder between the transformer or tap and the line

_____g. Patrol line to mid-point between open breaker and the end of the line if the fault remains on the line.

May be photocopied for student use.

SYSTEM KNOWLEDGE
(PHASE II)
UNIT 2

SUGGESTED ACTIVITIES

1. Suggested activities for the instructor:

   - Provide student with objective sheet.
   - Provide student with information sheet.
   - Discuss unit the specific objectives.
   - Discuss information sheet.
   - Show student local cooperative area map.
   - Discuss substation locations and feeds.
   - Discuss line feeds and possible switching location.
   - Give test.

2. Unit references:

   - *Power Line Technician.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

SYSTEM KNOWLEDGE
(PHASE II)
UNIT 2

ANSWERS TO TEST

1. a. Low line voltage
   b. High line voltage
   c. Line outage
   d. Breaker operation
   e. Equipment failure

2. a. 4 e. 3
   b. 2 f. 7
   c. 6 g. 8
   d. 1 h. 5

3. (NOTE: Any five of the following answers are acceptable.)
   - Line voltage regulation
   - Capacitors on the line
   - Three-phase transformer banks
   - Number of consumers on the line
   - Length of line to be switched
   - Overcurrent protection size

4. a, c, d

5. - Wear eye and head protection
   - Check the blades visually to see that they are open
   - Lock the switch handle open and place hold card
   - Close the switch immediately if the arc does not extinguish itself

6. a, b, c, e, f, g, h, i, j, k

SYSTEM KNOWLEDGE
(PHASE II)
UNIT 2

TEST

NAME _____ SCORE _____

1. List problems associated with line switching.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

2. Arrange in order the steps to follow when switching line. Place a "1" before the first step, a "2" before the second step, and so on.

   _____a. Phase the circuits together that are to be connected

   _____b. Check amperage on the line which is to carry the additional load

   _____c. Receive clearance from dispatcher

   _____d. Check amperage on the line to be switched

   _____e. Check breaker size on the line to which the additional load is to be added

   _____f. Connect circuits together

   _____g. Open switched line at opposite end of circuit

   _____h. Notify the dispatcher of the location and amount of line to be switched

3. List five of the factors involved in line switching.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

May be photocopied for student use.

TEST

4. Select from a list precautions to observe with line voltage regulators on a switched line. Place an "X" in front of the precautions to observe.

_____a. Set and lock the regulator in the Neutral position

_____b. Disregard the regulator operation

_____c. Reconnect the regulator for reverse power flow

_____d. Disconnect the regulator from the circuit

5. List precautions to observe when opening a line switch.

a. _____

b. _____

c. _____

d. _____

6. Select from a list areas and locations of importance to the line technician. Place an "X" in front of the areas and locations.

_____a. Oil circuit recloser locations and sizes

_____b. Substation locations

_____c. Sectionalizer locations and sizes

_____d. Pole sizes

_____e. Capacitor locations

_____f. Substation areas of feed

_____g. Line fuse locations and sizes

_____h. Line regulator locations

_____i. Line switch locations

_____j. Locations of emergency loads

_____k. Locations of dual feeds

May be photocopied for student use.

CONVERSIONS
UNIT 3

SUGGESTED ACTIVITIES

1. Suggested activities for instructor:

   - Provide student with objective sheet.
   - Provide student with information sheet.
   - Make transparency.
   - Discuss unit and specific objectives.
   - Discuss information sheet.
   - Show films and other supplemental materials on conversion.
   - Give test.

2. Unit reference

   - *Power Line Technician.* Stillwater, OK: Oklahoma Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, 1978.

CONVERSIONS
UNIT 3

ANSWERS TO TEST

1. • Single-phase to V-phase
   • Single-phase to three-phase
   • V-phase to three-phase
   • Conversion to a higher voltage
   • Conversion to a larger conductor

2. a. 5 e. 2
   b. 6 f. 1
   c. 4 g. 7
   d. 3 h. 8

3. a. 3 h. 6
   b. 4 i. 7
   c. 11 j. 12
   d. 10 k. 1
   e. 8 l. 13
   f. 5 m. 9
   g. 2

4. a. Line amperage is reduced to one-half of the original amperage
   b. Line voltage drop is reduced
   c. Voltage conversion
   d. Smaller conductor may be used

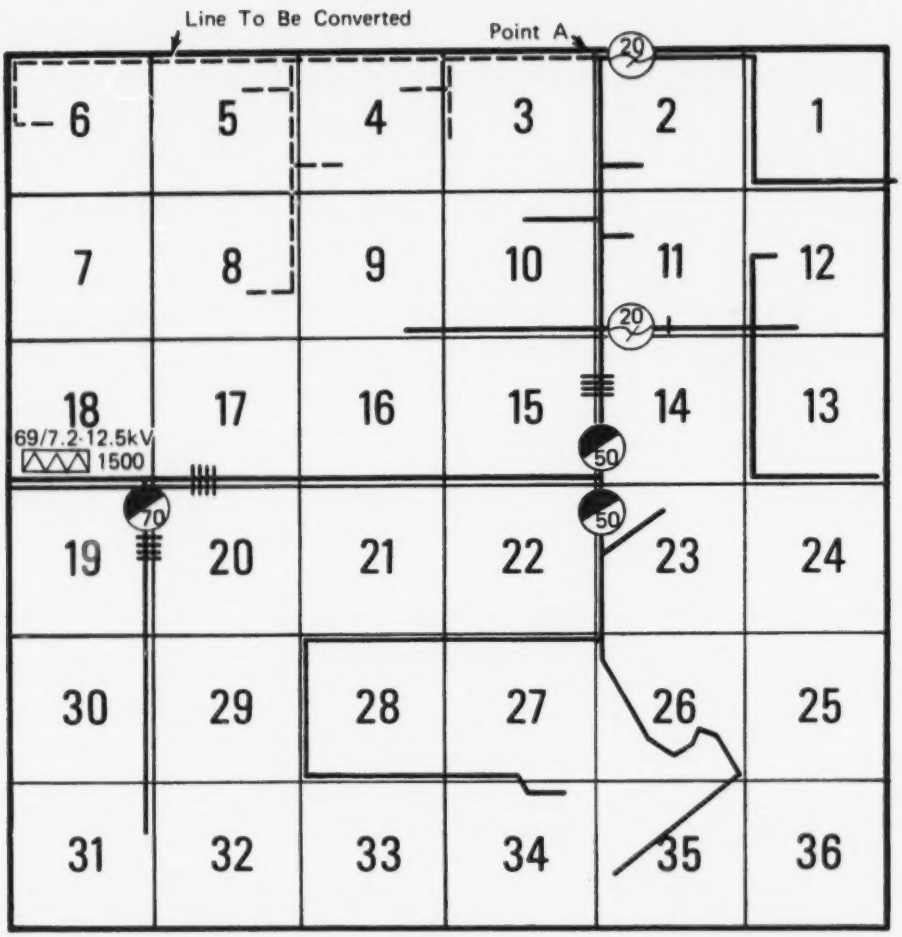
5. a, b, d, e, f

ANSWERS TO TEST

6. a. 3
   b. 5
   c. 2
   d. 6
   e. 1
   f. 4
   g. 7

7. a. 4
   b. 1
   c. 5
   d. 3
   e. 2
   f. 6
   g. 7

Changing A Substation Feed Area To A Higher Voltage (Example)



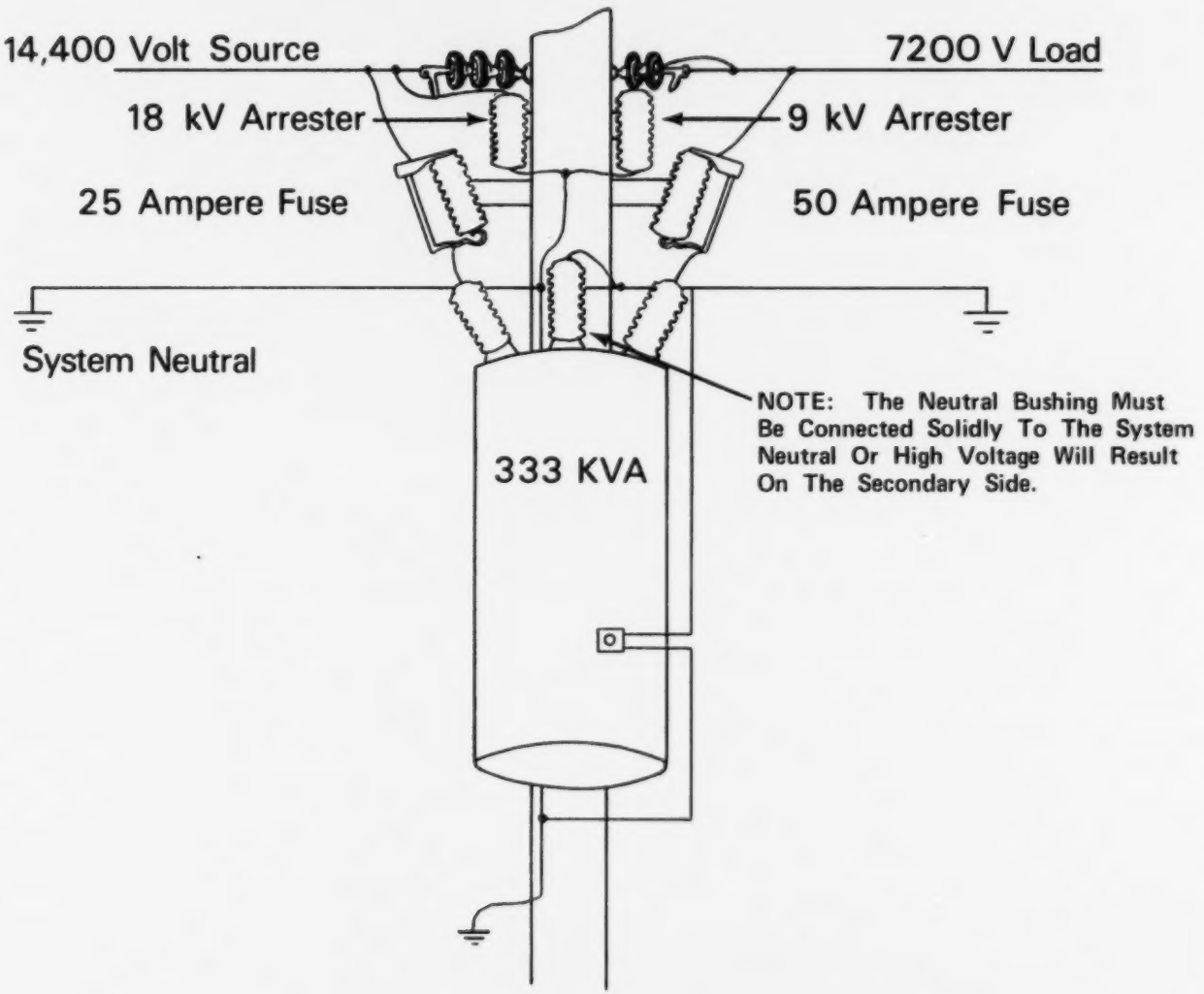
Example:

1. Reinsulate all poles in section of line tc converted
2. Install 333 kVA autotransformers at Point "A"
3. Disconnect all transformers in section of line to be converted
4. Connect autotransformer at Point "A" to feed line being converted with 14.4 kV
5. Change all transformers in section being converted to 14.4 kV transformers and connect newly installed transformers to the line as they are installed

TM 1

May be photocopied for student use.

Autotransformer Protection


14,400 Volt Source
7200 V Load
18 kV Arrester
9 kV Arrester
25 Ampere Fuse
50 Ampere Fuse
System Neutral
333 KVA
NOTE: The Neutral Bushing Must Be Connected Solidly To The System Neutral Or High Voltage Will Result On The Secondary Side.

May be photocopied for student use.

CONVERSIONS
UNIT 3

TEST

NAME _____ SCORE _____

1. List types of conversions.

   a. _____

   b. _____

   c. _____

   d. _____

   e. _____

2. Arrange in order the steps to convert a primary line to a higher voltage. Place a "1" before the first step, a "2" before the second step, and so on.

   _____a. Connect the auto or two-winding transformer to feed the converted line with the higher voltage

   _____b. Change all transformers on the converted line to the higher voltage transformer

   _____c. Disconnect all transformers on the line to be converted

   _____d. Install auto or two-winding transformer at the point where conversion is to start

   _____e. Change lightning arresters to a higher flashover level 18 kV

   _____f. Change all insulators to a higher voltage insulator

   _____g. Beware of backfeed from other lines, overhead, underground, and other utilities

   _____h. Call the "One Call System" in your state

3. Arrange in order the steps to change a substation feed area to a higher voltage. Place a "1" before the first step, a "2" before the second step, and so on.

   _____a. Convert the substation to the higher voltage (14,400 V)

   _____b. Disconnect all distribution circuits at the substation

   _____c. Change all transformers on the circuit being converted to 14,400-volt transformers and connect to the line

May be photocopied for student use.

TEST

_____d. Energize the circuit being converted at the substation with 14,400 volts

_____e. Disconnect all transformers on the circuit being converted

_____f. Connect the auto or two-winding transformers to transform 14,400 volts to 7,200 volts

_____g. Install auto or two-winding transformers on each phase at the substation

_____h. Reconnect all distribution circuits at the substation

_____i. Install auto or two-winding transformers a short way from the substation on the circuit to be converted (14,400 to 7,200 volts)

_____j. Remove the autotransformers at the substation that were feeding the converted circuit

_____k. Reinsulate all poles in the substation feed area to 14,400-volt insulation

_____l. Move the disconnected autotransformers to a point beyond the autotransformers on the converted circuit and convert the section of line between the autotransformers

_____m. Disconnect the autotransformers at the substation on the circuit being converted

4. Explain benefits of converting to a higher voltage.

a. What happens to line amperage when the voltage is doubled?

_____

b. What happens to line voltage drop?

_____

c. What may be accomplished without changing the conductor?

_____

d. What conductor may be used?

_____

May be photocopied for student use.

TEST

5. Select from a list precautions to observe with autotransformers. Place an "X" in front of the correct precautions.

_____a. Connect the neutral bushing solidly to the system neutral

_____b. Limit voltage transformation to no greater than three to one

_____c. Install with line drop compensator set at four

_____d. Install with overcurrent protection

_____e. Install with overvoltage protection

_____f. Limit the fault current through an autotransformer to 25 times its rated current

6. Arrange in order the steps to convert a single-phase line to V-phase. Place a "1" before the first step, a "2" before the second step, and so on.

_____a. Install crossarms with hardware for the additional phase

_____b. Add down guy to dead end and vertical angle pole

_____c. Check all right-of-ways for adequate clearance

_____d. String conductor for additional phase

_____e. Check all poles for soundness

_____f. Lower neutral four feet on all vertical corners and angle poles

_____g. Sag and tie in the conductor on the crossarm

7. Arrange in order the steps to convert a single-phase line to three-phase. Place a " 1" before the first step, a " 2" before the second step, and so on.

_____a. Lower neutral eight feet on all vertical corners and vertical angles

_____b. Check all poles for size and soundness

_____c. Add additional down guys to all dead ends and vertical angle poles

_____d. Install crossarms with hardware on each end for the additional phases

_____e. Check all right-of-ways for adequate clearance

_____f. String conductors for the additional phases

_____g. Pull the additional conductors to sag and tie in on the crossarms

May be photocopied for student use.

A CIMC "RAINBOW PROGRAM"

FOR STANDARDS OF TEACHING EXCELLENCE

One very important factor contributing to higher student performance is the expectation of parents and teachers. Experience suggests that teachers and parents who expect student success find that students perform better, attend class more regularly, have positive attitudes, and stay in school longer. The students' success and confidence in their ability to learn may cause additional growth and behaviors that exert a positive influence throughout life.

STUDENT'S PROMISE

Let it be publicly known that students in this program [illegible] high expe[illegible]

I recognize that America's future is dependent on my success in school.
I will attend school regularly.
I will keep regular study hours at home.
I will read each day at home.
I will never accept failure.
I will accept responsibility for my school challenges.
I will respect the rights and feelings of others at home, school, and work.
I will develop positive qualities in myself that my friends will admire.
If I have difficulty, I will insist on help with my school work.
If I have difficulty, I will always try harder.
I will ask my teacher for clear learning objectives.
I will practice good citizenship skills at home, school, and work.
I will keep my parents/guardians informed daily about my school activities.
I will develop goals for school, home, and work.
I will seek advice from my teachers, parents/guardians, and counselors on career guidance.
I will constantly practice the skills of a good student.

CIMC

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Power Line Technician

Second Edition

Module G

- Troubleshooting (Primary Line)
- System Knowledge (Phase II)
- Conversions

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CIMC

Student Workbook

97-012246

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1500 West Seventh Avenue
Stillwater, OK 74074-4364
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TI3021

Power Line Technician: Module G

Student Workbook

Developed by the
Curriculum and Instructional Materials Center
Oklahoma Department of Vocational and Technical Education

97-012246

TI3021

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TABLE OF CONTENTS

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4. General Safety

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1. Personal and Job Safety
2. Communications
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5. Overhead Construction
6. Underground Distribution Construction
7. Personal Climbing Tools and Equipment
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3. Work Procedures (Hot Line, Basket, Hot Stick)
4. Troubleshooting (Secondary)

MODULE G

1. Troubleshooting (Primary Line)
2. System Knowledge (Phase II)
3. Conversions

TROUBLESHOOTING
(PRIMARY LINE)
UNIT 1

UNIT OBJECTIVE

After completion of this unit, the student should be able to list problems which will be encountered while troubleshooting primary lines and match the problems to possible causes. The student should be able to list precautions to observe while troubleshooting and arrange in order the steps in troubleshooting. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match troubleshooting problems to possible causes.
2. Arrange in order the troubleshooting procedures to follow for various problems.
3. List precautions to observe when troubleshooting primary lines.
4. Arrange in order the steps for troubleshooting a primary line outage.

TROUBLESHOOTING
(PRIMARY LINE)
UNIT 1

INFORMATION SHEET

1. Match troubleshooting problems to possible causes.

- Low line voltage
    1. Line overloaded
    2. Voltage regulator inoperative
    3. Capacitors not in operation
    4. Backfeed on open line from another source

       Example: Transformer bank or other utility
- High line voltage
    1. Voltage regulator inoperative
    2. Too much capacitance on the line
- Blinking lights
    1. Broken or burned connection
    2. Cattle rubbing down guy
    3. Trees blowing into line
    4. Contact with another line
    5. Swinging phase
    6. Broken insulator
- Extreme voltage swing
    1. Intermittent heavy load on line
    2. Oil field pumps not balanced
    3. Voltage regulator inoperative
    4. Open phase or phases in common

INFORMATION SHEET

- Radio and television interference
  1. Loose or burned connection
  2. Transformer breaking down
  3. Insulator breaking down
  4. Loose hardware
  5. Broken or loose pole ground
  6. Ground wire too close to hardware
- Galvanic damage
  1. Pipeline rectifier set too high
  2. Poor ground condition
  3. High wattage radio station nearby
  4. Dissimilar metals underground
- Line outage
  1. Small animal or bird on conductor
  2. Trees in line
  3. Cattle rubbing down guy
  4. Lightning
  5. Downed pole
  6. Broken insulator
  7. Lightning arrester shorted
  8. Gap set too close on lightning arrester
  9. High wind blowing foreign objects into line
  10. Transformer faulted
  11. Breaker faulted
  12. Broken conductor

INFORMATION SHEET

2. Arrange in order the troubleshooting procedures to follow for various problems.

- Low line voltage
  1. Measure line amperage
  2. Check conductor size
  3. Check voltage regulator
  4. Check line capacitors
  5. Check reclosers
  6. Record information
- High line voltage
  1. Check voltage regulator
  2. Check line capacitors

  (NOTE: If line capacitors are operated by voltage, power factor, or thermal action, the operating device may have malfunctioned and failed to disconnect the capacitors from the line.)
- Blinking lights
  1. Inspect line visually for loose or burned connections
  2. Check for tree in line
  3. Patrol line for signs of cattle rubbing down guys
  4. Check for swinging phase
  5. Set recording voltmeters along the line
  6. Check with consumers along the line to locate source of blinking
- Extreme voltage swing
  1. Check for heavy intermittent load
  2. Check for open phase or phases in common
  3. Check for oil field or other types of unbalanced pumps
  4. Check voltage regulator for proper operation

INFORMATION SHEET

- Radio and television interference

  1. Check with consumers to find radius of interference
  2. Use radio or noise locator to localize the source of interference
  3. Check for loose connections
  4. Disconnect transformer to see if interference source is on a secondary or in the transformer
  5. Check fence chargers in the area

- Line outage

  1. Locate consumer on your system map
  2. Trace phase to which consumer is connected to breaker or fuse which protects that phase
  3. Reset the breaker or re-fuse the line

3. List precautions to observe when troubleshooting primary lines.

   (CAUTION: Troubleshooting requires a constant vigilance for the probability of unknown hazards. Every safety precaution should be observed at all times.)

   - Assume all conductors are energized unless grounds are installed within sight

     (NOTE: Telephone lines or fences may be energized from a downed phase.)

   - Do not place yourself in series with an open neutral or ground
   - Wear your personal protective equipment

     (NOTE: Rubber gloves, hard hat, and eye protection are especially important when troubleshooting because of the possibility of unknown hazards.)

   - Place hold card at disconnect point

4. Arrange in order the steps for troubleshooting a primary line outage. (Transparency 1)

   - Reset the open breaker

     (NOTE: A preliminary check of the faulted line may determine the cause before resetting the breaker.)

   - Patrol line to mid-point between open breaker and the end of the line if the fault remains on the line

INFORMATION SHEET

- Open line at mid-point if the fault is not located

  (NOTE: The line should be opened as near as possible to mid-point or at the next connection or switch.)

- Return to open breaker and reset it

  (NOTE: If breaker holds, the fault is between the opening and the end of the line. If the breaker does not hold, the fault is between the open breaker and the opening in the line.)

- Disconnect transformers and taps in the section of line that is faulted

- Reconnect line at mid-point with a temporary fuse holder

- Reconnect transformers and taps with a temporary fuse holder between the transformer or tap and the line

  (NOTE: If fuse does not blow, reconnect transformer to the line.)

SYSTEM KNOWLEDGE
(PHASE II)
UNIT 2

UNIT OBJECTIVE

After completion of this unit, the student should be able to list problems which can be caused by line switching and be able to follow the steps to switch line. The student should be able to list precautions to observe with line switching and voltage regulators on switched line. The student should be able to select from a list the areas and locations of importance to the line technician. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List problems associated with line switching.
2. Arrange in order the steps to follow when switching line.
3. List factors involved in line switching.
4. Select from a list precautions to observe with line voltage regulators on a switched line.
5. List precautions to observe when opening a line switch.
6. Select from a list areas and locations of importance to the line technician.

SYSTEM KNOWLEDGE
(PHASE II)
UNIT 2

INFORMATION SHEET

1. List problems associated with line switching.

   - Low line voltage
   - High line voltage
   - Line outage
   - Breaker operation
   - Equipment failure

2. Arrange in order the steps to follow when switching line.

   (NOTE: Use phasing sticks when phases or circuits are being switched. If a large amount of line is to be switched, the power supplier should be notified.)

   - Check amperage on the line to be switched
   - Check amperage on the line which is to carry the additional load
   - Check breaker size on the line to which additional load is to be added

     (NOTE: If the circuit which is to carry the additional load is already loaded, an alternate method should be considered.)

   - Phase the circuits together that are to be connected
   - Notify the dispatcher of the location and amount of line to be switched
   - Receive clearance from dispatcher
   - Connect circuits together
   - Open switched line at opposite end of circuit

3. List factors involved in line switching.

   - Line voltage regulation
   - Capacitors on the line
   - Three-phase transformer banks

INFORMATION SHEET

- Number of consumers on the line
- Length of line to be switched
- Overcurrent protection size

  Examples: OCR, sectionalizer, fuse

4. Select from a list precautions to observe with line voltage regulators on a switched line.

   (CAUTION: The three precautions listed are alternatives and only one is to be used.)

   - Disconnect the regulator from the circuit
   - Set and lock the regulator in the Neutral position
   - Reconnect the regulator for reverse power flow

5. List precautions to observe when opening a line switch.

   - Wear eye and head protection
   - Check the blades visually to see that they are open
   - Lock the switch handle open and place hold card
   - Close the switch immediately if the arc does not extinguish itself

6. Select from a list areas and locations of importance to the line technician.

   - Substation locations
   - Substation areas of feed
   - Line regulator locations
   - Capacitor locations
   - Oil circuit recloser locations and sizes
   - Sectionalizer locations and sizes
   - Line fuse locations and sizes
   - Line switch locations
   - Locations of emergency loads
   - Locations of dual feeds

CONVERSIONS
UNIT 3

UNIT OBJECTIVE

After completion of this unit, the student should be able to arrange in order the steps to safely convert a primary line to additional phases or to a higher voltage. This knowledge will be evidenced by scoring 85 percent on the unit test.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. List types of conversions.
2. Arrange in order the steps to convert a primary line to a higher voltage.
3. Arrange in order the steps to change a substation feed area to a higher voltage.
4. Explain benefits of converting to a higher voltage.
5. Select from a list precautions to observe with autotransformers.
6. Arrange in order the steps to convert a single-phase line to V-phase.
7. Arrange in order the steps to convert a single-phase line to three-phase.

CONVERSIONS
UNIT 3

INFORMATION SHEET

1. List types of conversions.

   - Single-phase to V-phase
   - Single-phase to three-phase
   - V-phase to three-phase
   - Conversion to a higher voltage
   - Conversion to a larger conductor

   (NOTE: Use all proper personal protective equipment related to corresponding voltage.)

2. Arrange in order the steps to convert a primary line to a higher voltage.

   - Change all insulators to a higher voltage insulator
   - Change lightning arresters to a higher flashover level (18 kV)
   - Install auto or two-winding transformer at the point where conversion is to start
   - Disconnect all transformers on the line to be converted
   - Connect the auto or two-winding transformer to feed the converted line with the higher voltage
   - Change all transformers on the converted line to the higher voltage transformer

   (NOTE: The preceding method is used to convert a line from the end of the line back to the substation.)

   - Beware of backfeed from other lines, overhead, underground, and other utilities
   - Call the "One Call System" in your state

3. Arrange in order the steps to change a substation feed area to a higher voltage. (Transparency 1)

   - Reinsulate all poles in the substation feed area to 14,400-volt insulation
   - Install auto or two-winding transformers on each phase at the substation

INFORMATION SHEET

- Convert the substation to the higher voltage (14,400 volts)

  (NOTE: The power transformer, voltage regulator, lightning arresters, and oil circuit reclosers must be changed to meet the higher voltage requirements.)

- Disconnect all distribution circuits at the substation
- Connect the auto or two-winding transformers to transform 14,400 volts to 7,200 volts
- Reconnect all distribution circuits at the substation
- Install auto or two-winding transformers a short way from the substation on the circuit to be converted (14,400 to 7,200)
- Disconnect all transformers on the circuit being converted
- Disconnect the autotransformers at the substation on the circuit being converted
- Energize the circuit being converted at the substation with 14,400 volts
- Change all transformers on the circuit being converted to 14,400-volt transformers and connect to the line
- Remove the autotransformers at the substation that were feeding the converted circuit
- Move the disconnected autotransformers to a point beyond the autotransformers on the converted circuit and convert the section of line between the autotransformers

  (NOTE: The alternate method of line voltage conversion is more expensive because more auto or two-winding transformers are required. However, the alternate method may be required due to the timing of the substation change and the time required to reinsulate the entire feed area of a substation.)

4. Explain benefits of converting to a higher voltage.

   - Line amperage is reduced to one-half of the original amperage when the voltage is doubled
   - Line voltage drop is reduced
   - Voltage conversion may be accomplished without changing the conductor
   - Smaller conductor may be used

5. Select from a list precautions to observe with autotransformers.

   - Install with overvoltage protection
   - Install with overcurrent protection

INFORMATION SHEET

- Limit the fault current through an autotransformer to 25 times its rated current
- Limit voltage transformation to no greater than three to one
- Connect the neutral bushing solidly to the system neutral

(CAUTION: Autotransformer will transform voltage in either direction. Care should be taken to connect the autotransformer so that the desired voltage will be fed to the correct conductor.)

6. Arrange in order the steps to convert a single-phase line to V-phase.
   - Check all poles for soundness
   - Check all right-of-ways for adequate clearance
   - Install crossarms with hardware for the additional phase
   - Lower neutral four feet on all vertical corners and angle poles
   - Add down guy to dead end and vertical angle pole
   - String conductor for additional phase
   - Sag and tie in the conductor on the crossarm
7. Arrange in order the steps to convert a single-phase line to three-phase.
   - Check all poles for size and soundness
   - Check all right-of-ways for adequate clearance
   - Install crossarms with hardware on each end for the additional phases
   - Lower neutral eight feet on all vertical corners and vertical angles
   - Add additional down guys to all dead ends and vertical angle poles
   - String conductors for the additional phases
   - Pull the additional conductors to sag and tie in on the crossarms

   (CAUTION: Pulling in a conductor on a pole with an energized conductor should be done with a controlled tension wire stringing reel. The wire stringing reel and the truck or trailer that it is mounted on must be grounded. Attach a running ground to conductor being pulled in.)

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STUDENT'S PROMISE

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I will never accept failure.
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I will develop positive qualities in myself that my friends will admire.
If I have difficulty, I will insist on help with my school work.
If I have difficulty, I will always try harder.
I will ask my teacher for clear learning objectives.
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I will keep my parents/guardians informed daily about my school activities.
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I will constantly practice the skills of a good student.

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